# LUNG AUSCULTATION AS A PREDICTOR OF LUNG LESIONS AND BOVINE RESPIRATORY DISEASE OUTCOME IN FEEDYARD CATTLE

by

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# Abstract

Bovine respiratory disease complex (BRDC) is the most common, and costly, disease in feedyard cattle. A review of the literature shows a correlation between the diagnosis of BRDC ante-mortem and respiratory lesions at slaughter. The objectives of the studies reported here were to: 1) validate a thoracic auscultation scoring system by correlating ante-mortem lung sounds with post-mortem lung lesions and 2) evaluate thoracic auscultation and rectal temperature as diagnostic tools to predict case outcome in the feeder cattle treated for BRDC.

First, a prospective cohort study involving thirty four head of cattle that had been realized from commercial cattle feeding operations were used to validate the use of a lung auscultation scoring system to identify cattle suffering from BRDC. Ante-mortem auscultation scores were compared to post-mortem lung lesions evaluated using a previously described scoring system. There was a positive correlation ($P < .0001$) between ante-mortem lung auscultation scores and post-mortem lung lesion scores in the population of feeder cattle that were tested.

Subsequently, a retrospective cohort study was conducted using data obtained from three commercial feedyards. Cattle enrolled in the study (n = 4,341 head) were treated for BRDC between January 2007 to October 2007 by trained feedyard personnel. Data recorded included animal identification, rectal temperature, lung score, and antibiotic therapy at first treatment. Treatment outcome data were recorded by feedyard personnel utilizing an animal health computer. The outcome data tracked for this study included subsequent BRDC treatment or death of the animal. Our findings indicated that as lung auscultation score ($P < .0001$) or rectal temperature ($P < .0001$) increased there was an increased risk for cattle to require a second

BRDC treatment. Also, we observed an increased risk for death loss in cattle with higher lung auscultation scores ($P < .0001$) or higher rectal temperature ($P < .0001$) at the time of treatment for BRDC. We have demonstrated that lung auscultation score and rectal temperature can be used as tools to predict treatment outcome in cattle treated for BRDC. Future research with these tools could be used to develop more precise therapeutic protocols for BRDC in feeder cattle.

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The field study data was collected from anonymous feedyards in Kansas, Nebraska, and Washington State; I owe each feedyard a sincere thank you for allowing me access to their animal health computers and records. Drs. Tom Noffsinger and Wade Taylor gained my access to these feedyards and deserve a sincere thank you for their efforts. I also appreciate their willingness to help me understand the role of a feedyard consulting veterinarian and their patience in teaching me to use a stethoscope effectively in a feedyard.

# Dedication

This thesis is dedicated to my wife Sarah and our son Kerrick. Additionally to my family; parents Kenny and Terry, brothers Kevin (Misty, Bethany and Leo), Kris (Carly), and Kelly, sisters Kim and Karen (Wes), and Sarah's parents Mike and Barb for their unending love and support. Without their support none of my accomplishments would have been possible.

In memory of my grandparents, Leo and Helen, Bud and Frieda and my cousin Beau who was taken from us too soon; may they rest in peace.

# CHAPTER 1 - Bovine Respiratory Disease Complex, A Literature Review

## Disease in the Feedyard

Disease in the feedyard is typically broken into three broad categories: respiratory, digestive, and other diseases. Infectious bronchopneumonia in feedyard cattle is generally combined into one broad category—bovine respiratory disease complex (BRDC). Acute interstitial pneumonia (AIP) is a respiratory disease syndrome that has not been linked to typical respiratory disease pathogens. Woolums *et al.* (2005) classified AIP as a separate disease entity from BRDC[49]. However, in the studies detailed below it is clear that AIP is inconsistently classified.

Digestive diseases can include ailments such as bloat, acidosis, and coccidiosis. Diseases affecting the musculoskeletal, urogenital, and central nervous systems or diseases of unknown origin are reserved for the "others" category. Mortality patterns of feedyard disease are studied extensively in veterinary medicine with respiratory disease being the most common, and costly, disease in feedyard cattle.

Vogel and Parrott (1994) published a feedyard mortality survey detailing data from 59 feedyards in seven Midwestern states from January 1990 – May 1993. The number of cattle in this study totaled 38,593,575 head. Their analysis primarily focused on a characterization of month to month death loss from digestive, respiratory, and other causes. Total death loss, or death from all etiologies, averaged 0.268% of occupancy (i.e., 27 deaths per 10,000 cattle on feed) by month over the three and half years[44].

These findings for respiratory mortality as a percentage of total occupancy averaged 0.128% per month and ranged from 0.073% to 0.234%. That was a 321% deviation based on the month of the year and was highest in the late fall and early winter months. The authors speculated that the difference in monthly mortality may be due to seasonal changes in weather patterns as well as variation in the type and risk of cattle entering the feedyards[44].

Digestive deaths averaged 0.061% of occupancy and ranged from 0.049% to 0.078%. Other causes of death averaged 0.078% and ranged from 0.047% to 0.119%. Each mortality category was also reported as a percentage of total death loss; deaths due to BRDC were 44.1%, digestive disorders were 25.9%, and "other" causes accounted for 28.6% of all deaths over the three and a half year period[44] (Table 1.1).

**Table 1.1 Percent mortality in the feedyard from respiratory, digestive, and other diseases**

| | | | Mortality (%) | | |
|---|---|---|---|---|---|
| Study | Year | Head (N) | Respiratory | Digestive | Other |
| Vogel and Parrott | 1994 | 38,593,575 | 44.1 | 25.9 | 28.6 |
| Edwards | 1996 | 5,972,758 | 56.7 | 26.3 | 18.4 |
| NAHMS | 2000 | 21,753,082 | 56.8 | 23.4 | 19.8 |
| Woolums *et al.* | 2005 | 2,495,439 | 66.2* | 19.8 | 15.2 |

*Percentage of cattle affected by BRD + percentage of cattle affected by AIP

Edwards (1996) published yearly percentages of morbidity and mortality with data collected from 1986 to 1994. These data were from Midwestern feedyards in which the author was the consulting veterinarian representing approximately six million head of cattle on feed during that time. Morbidity from respiratory disease averaged 75.4%, digestive disorders 4.8%, and other diseases 19.6%. Mortality figures were as follows: respiratory disease 56.7%, digestive diseases 26.3%, and other diseases 18.4% of all mortality in those feedyards[8] (Table 1.1).

The United States Department of Agriculture (USDA) established the National Animal Health Monitoring System (NAHMS) in 1983 to collect, analyze, and disseminate data on animal health, management, and productivity across the United States. The sentinel feedyard monitoring program was developed under NAHMS to monitor cattle in feedyards and serves as a benchmarking tool. Data were collected for 21,753,082 head of cattle from 121 feedyards in 12 states from 1994 to 1999 and published in 2000. Researchers found that the proportion of death loss from respiratory disease appeared to increase from 1994 to 1999 while the proportion of digestive disease death loss decreased[40] (Table 1.2).

**Table 1.2 Percent mortality in the feedyard from respiratory, digestive, and other disease from a survey of 121 feedyards over six years**

| Year | Respiratory | Digestive | Other |
|---|---|---|---|
| 1994 | 52.1 | 27 | 20.7 |
| 1995 | 55.4 | 25 | 19.8 |
| 1996 | 55.4 | 24 | 20.6 |
| 1997 | 49.6 | 21 | 19 |
| 1998 | 57 | 23 | 19.8 |
| 1999 | 61.5 | 20 | 19 |

Source: NAHMS, 2000

Loneragan *et al.* (2001) published a study evaluating trends in feedyard cattle mortality ratios over time, monthly proportional mortality ratios of cattle by primary body system affected, and risk of death by type of animal among feedyards participating in the NAHMS sentinel feedyard monitoring program. They found that the mortality ratio tended to increase ($P = 0.09$)

from 10.3 deaths per 1,000 head of cattle in 1994 to 14.2 deaths per 1,000 head of cattle in 1999 for all etiologies (Figure 1.1). Respiratory mortality ratios increased from 5.4 deaths per 1000 head in 1994 to 8.7 per 1000 head in 1999. Furthermore, digestive disease mortality ratios were 2.8 per 1000 head in 1994 and 1999 and other disease mortality ratios were 2.1 and 2.7 per 1000 head. Additionally, they found that cattle entering the feedyard in 1999 had a significant increase in risk (relative risk, 1.46) of dying from respiratory disease in comparison to cattle entering the feedyard in 1994[18].

**Figure 1.1 Yearly mortality ratios (No. of deaths/1,000 animals entering the feedyard) for 21,753,082 cattle in 121 feedyards in the United States**

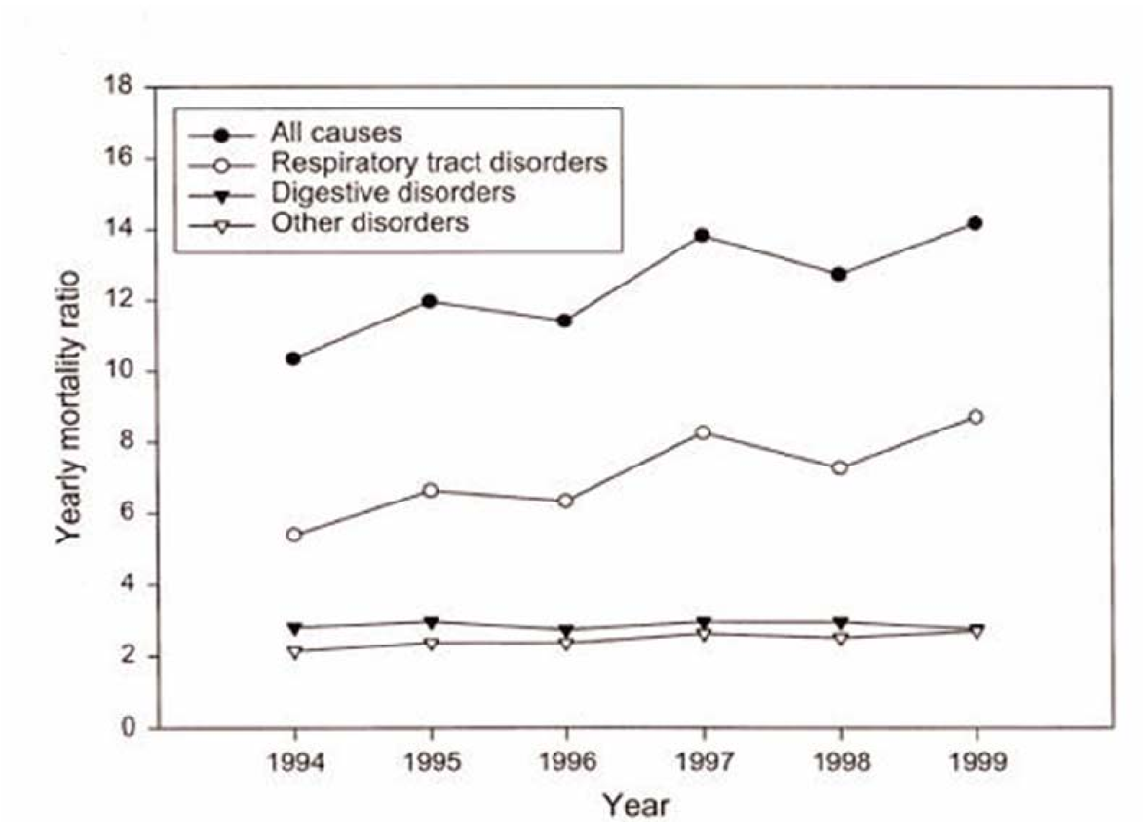



Figure from Loneragan *et al.*, 2001

Woolums *et al.* (2005) found BRDC to be the number one cause of both morbidity and mortality in a cross-sectional survey sent to 561 feedyards in 21 states (12.8% of feedyards responded representing 2,495,439 head of cattle). They found that 12.57% of placements were treated for BRDC and 0.75% died from BRDC. Of these cattle on feed they also found that 1.28%, 1.56%, and 2.63% of all placements were treated for AIP, digestive diseases, and other diseases, respectively. Additionally, 0.13%, 0.27%, and 0.15% died due to AIP, digestive diseases, and other diseases, respectively[49].

All studies in this literature review agree that respiratory disease is the number one cause of morbidity and mortality in feeder cattle in the United States. Loneragan *et al.* (2001) showed that respiratory mortality in feeder cattle was on the rise while the other diseases in the feedyard remained the same or were decreasing in incidence[18]. This is quite surprising and alarming considering advancements in pharmaceutical technologies since 1990. Several new antibiotic compounds have received approval from the Food and Drug Administration for use in cattle to treat BRDC since 1990 (Table 1.3).

**Table 1.3 Antibiotics approved for use in cattle since 1992**

| Generic | Trade | NADA # | Date of FDA Approval |
|---|---|---|---|
| Tilmicosin | Micotil | 140-929 | March 24, 1992 |
| Enrofloxacin | Baytril | 141-068 | July 24, 1998 |
| Florfenicol | Nuflor | 141-063 | December 17, 1998 |
| Danofloxacin | A180 | 141-207 | September 20, 2002 |
| Ceftiofur crystalline free acid | Excede | 141-209 | September 5, 2003 |
| Tulathromycin | Draxxin | 141-244 | May 24, 2005 |

Source: Freedom of Information Summaries

## Economic effects

The most apparent economic losses are seen in death loss and when calves are sold prematurely (or railed). Researchers at Texas A&M reported that calves railed had losses that ranged from $240 to $307 per head[28-36]. More difficult figures to attain are costs associated with interest, labor, veterinary services, opportunity costs, feed costs, yardage, etc.[17].

Significant amounts of money are spent on preventing and treating BRDC in the feedyard in just vaccines and antibiotics alone. Using NAHMS data, Loneragan (2001) estimated treatment costs in the calendar year of 1999 to be 45.7 million dollars[17]. That estimate is significantly lower than the $624 million estimated by Smith in 1996[26].

The Texas A&M Ranch to Rail report is an information feedback system that follows producer's calves from their ranch through the feedyard. This report collects data from birth to harvest in order to provide the producer information on how their calf crop fits the needs of the beef industry. Data on live performance, carcass, and financial information was collected yearly from 1992 to 2001. Sick calves (treatment for any disease) incurred medicine costs the ranged from $21.39 to $44.55 (an average of $28.76) above those of their healthy counterparts over the entire feeding period[28-36].

Treatment costs associated with one treatment of BRDC was second ($12.59 per treatment) only to treatment of AIP ($13.33 per treatment); these costs included only pharmaceuticals and other expendables (needles, syringes, etc) in the NAHMS survey data[41]. The USDA Animal and Plant Health Inspection Service (APHIS) reported (2001) that the cost of treating respiratory disease once ranged from $7.87 to $15.57 per head depending on the particular treatment regimen[39]. Undoubtedly, these figures would be much higher with the price of today's newer antimicrobials.

The exact cost of BRDC to the feedyard industry is difficult to accurately calculate. However, there is significant documentation of BRDC's effects on performance and carcass traits in the literature. Irsik *et al.* (2006) analyzed pen by pen (n=673 pens; 53,890 head) mortality effects on feed conversion (FC), average daily gain (ADG), and added costs (AC) with data obtained from customer closeout sheets from two western Kansas commercial feedyards[14]. They found trends that they used to provide some "rules of thumb":

1. Feed Conversion: FC ratio increased by 0.27 lb (0.12 kg) for each percentage increase in death loss
2. Average Daily Gain: ADG decreased by 0.08 lb (0.04 kg) for each percentage increase in death loss
3. Added Costs: AC increased by $1.00 per head for each percentage increase in death loss.

Snowder *et al.* (2006) found that calves with a diagnosis of BRDC had lower ADG (0.95 kg) in comparison to healthy animals (0.99 kg) ($P < 0.001$) with a difference of 0.04 kg[27]. Gardner *et al.* (1999), Van Donkersgoed *et al.* (1993), and Wittum and Perino (1995) found similar reductions in gain among treated versus untreated animals reporting 0.06 kg/d[10], 0.14 kg/d[42], and 0.04 kg/d[48], respectively.

There is mounting evidence that disease in feedyard cattle, notably BRDC, can have effects on carcass traits. Gardner *et al.* (1999) found that carcasses from untreated steers were fatter both externally ($P < 0.01$) based on subcutaneous fat measurements and internally ($P < 0.05$) based on percentages of kidney, pelvic, and heart fat. Untreated steers tended to have larger ($P = 0.12$) rib eye area (REA) than treated steers and subsequently had higher ($P < 0.04$) USDA yield grades. Slight reductions in marbling scores ($P = 0.16$) were also seen in steers treated for BRDC although not statistically significant. In this same study they found that steers with respiratory tract lesions had a lower ($P = 0.02$) dressing percentage than steers without lesions. Carcasses from steers without lesions at slaughter were also heavier ($P < 0.01$) and had more external ($P = 0.14$) and internal ($P < 0.01$) fat and tended to have a larger REA ($P = 0.15$)[10].

There are reports of a correlation between lung lesions at slaughter and a reduction in ADG compared to animals without lesions at slaughter. Gardner *et al.* (1999) found that steers without lesions at slaughter had 11% (1.58 vs. 1.40 kg/d, $P <0.01$) greater ADG than cattle with lesions. Additionally, steers with active bronchial lymph nodes had 18% lower ($P < 0.01$) ADG than steers with inactive bronchial lymph nodes[10]. Work done by Bryant *et al.* (1999) at the Great Plains Veterinary Educational Center showed that lesions present at slaughter had negative effects on ADG of 0.057 lb in single source calves ($P < 0.01$) to as high as 0.65 lb in calves from a commercial feedyard ($P < 0.01$)[3].

Researchers in South Africa found that the average negative effect of the presence of lung lesions at slaughter were a 0.023 kg/d reduction ($P = 0.02$) in ADG. Additionally, they also found the presence of lesions at slaughter was associated with a 5.5 day increase in days on feed (DOF)[37]. Wittum *et al.* (1996) found similar results, reporting that lesions at slaughter related to a 0.076 kg/d reduction in ADG[48].

Interestingly, all of the previous studies found disparity between animals treated for BRDC and lesions observed at slaughter. Wittum *et al.* (1996) found that 78% of animals clinically diagnosed and treated for BRDC had lesions at slaughter while 68% of cattle never diagnosed or treated for BRDC had lesions at slaughter[48]. Similarly, Gardner *et al.* (1999) found lesions in 48% of cattle diagnosed with BRDC and 29% in those never diagnosed with BRDC and Thompson *et al.* (2006) 55% and 39%, respectively[10,37]. Bryant *et al.* (1999) found more lung lesions at slaughter in cattle never diagnosed with BRDC (42%) versus those that had been diagnosed and treated for BRDC (40%)[3] (Table 1.4).

**Table 1.4 Percentage of lung lesions observed at slaughter from four studies**

| Study | Year | Head (N) | All Cattle(%)[1] | Treated (%)[2] | Untreated (%)[3] |
|---|---|---|---|---|---|
| Wittum et al. | 1996 | 469 | 72 | 78 | 68 |
| Gardner et al. | 1999 | 222 | 37 | 48 | 29 |
| Bryant et al. | 1999 | 439* | 42 | 40 | 42 |
| | | 599** | 54 | n/a | n/a |
| Thompson et al. | 2006 | 2036 | 43 | 55 | 39 |

1 - Percentage of all cattle that had lesions at slaughter, treated or non-treated
2 - Percentage of cattle diagnosed and treated for BRDC that had lesions at slaughter
3 - Percentage of cattle not diagnosed with BRDC (untreated) with lesions at slaughter
* - Single source, U.S. Meat Animal Research Center (MARC) calves
** - Calves from a commercial feedyard

It is important to note that researchers that have looked at the effects of both clinically diagnosed BRDC and BRDC diagnosed by way of lung lesions at slaughter have found that performance traits are correlated more closely with lesions found at slaughter than clinically diagnosed BRDC[3,10,37,48]. In a review of cattle disease effects on carcass traits, Larson (2005) discussed possible reasons for the lack of a significant association between clinically diagnosed BRDC and lesions evident at slaughter. Some factors leading to the lack of lesions in cattle diagnosed clinically with BRDC could include: transient infections not resulting in lung pathology, a full recovery from respiratory disease with complete resolution of lung lesions, and an incorrect clinical assessment for the presence of BRDC. Reasons for the presence of lesions at slaughter in cattle not diagnosed with BRDC could include: respiratory tract disease that was not accompanied by clinical signs of BRDC, the presence of chronic lung damage that occurred due to a BRDC event before the time of investigation, and an incorrect clinical assessment for the absence of BRDC at the time of evaluation[16].

## Diagnosing BRDC in the feedyard

In the U.S. feedyard system, disease detection starts with the pen riders. Pen riders are in the pens looking at cattle at least once per day for signs of any illnesses. Clinical signs that are used to identify cattle possibly afflicted with BRDC include respiratory rate, respiratory character, rumen fill, observed anorexia, nasal discharge, ocular discharge, and depression[2]. Cattle identified to be exhibiting these signs are then pulled (taken out of the pen for further examination) and taken to the hospital. Once at the hospital classical feedyard diagnostics consist of examining clinical signs and taking rectal temperatures. Decisions on therapeutic regimen are often outlined in a treatment protocol and are generally based on a rectal temperature greater than an arbitrary number, described as ≥39.7 ºC (103.5 ºF) by Duff and Galyean[7].

Cattle exhibiting the clinical signs mentioned above with normal rectal temperatures many times receive the diagnosis of a digestive disorder or other disease and do not receive treatment for BRDC. Rectal temperatures can vary from the influence of such factors as environmental temperature, relative humidity, exercise, excitement, and anxiety. These changes in rectal temperature are the result of physiologic change rather than a pathologic one[9]. Vogel *et al* (2007) found that for each unit increase in maximum ambient temperature, rectal temperature in all cattle pulled increased 0.07 ºF ($P < 0.01$)[45]. In the same study, they found that the rectal temperatures in cattle pulled and treated for BRDC had no association with a risk of retreatment or mortality[45].

Using elevated rectal temperature as the sole diagnostic tool beyond clinical signs is essentially treating on the basis of depression with undifferentiated fever. Treatments based solely on this may lead to unnecessary (and injudicious) antimicrobial use[2].

Perino and Apley (1998) described what may be a better protocol entailing the use of a clinical scoring system in conjunction with rectal temperatures. They described a clinical scoring system that could be used in clinical trials in a feedyard. Severity score criteria were as follows:

0 – Normal, no signs of disease

1 – Noticeable depression, signs of weakness are usually not apparent

2 – Marked depression, moderate signs of weakness may be apparent but without significantly altered gait

3 – Sever depression accompanied by signs of weakness such as altered gait

4 – Moribund, unable to rise

In this example, they suggested using the presence of a clinical score ≥ 1 in combination with a rectal temperature of ≥40 ºC (≥104 ºF) for treatment decisions[21].

Researchers have described other diagnostic possibilities but unfortunately, many are not timely enough to warrant use in treatment decisions chute-side. DeRosa *et al.* (1999) found that nasal swab cultures were predictive (96% correlation with transtracheal cultures) of the bacterial species causing lung pathology and they were genetically identical in 70% of the calves with BRDC[6]. The authors found antibiotic susceptibility of the isolates was similar in a majority of the cases; however, culture results take several days to obtain.

Acute phase proteins are soluble mediators released during tissue insult associated with disease. Several researchers are studying this acute-phase response and proteins that are being measured in cattle include fibrinogen, haptoglobin, serum amyloid-A, α-1-acid glycoprotein, ceruloplasmin, α-2-macoglobulin, and C-reactive protein[7]. Results of studies evaluating the acute phase response in relationship to BRDC are varied and often are not in agreement. Therefore, acute phase proteins are not a reliable indicator of disease as of yet.

Some authors suggest more technologically advanced diagnostic tests including infrared thermography or the use of a radio frequency implant containing a temperature probe for the early detection of disease[7]. To date, little research is available evaluating the accuracy of their use as diagnostic tools in a commercial feedyard setting.

## Etiology and pathogenesis

Discussing pathology, Cusack *et al.* (2003) stated that differentiation between the lesions caused by various BRDC agents is largely irrelevant; efforts should instead be spent on reducing or eliminating stressors that provide an opportunity for consolidation of the lungs by these pathogens[5]. However, a very brief overview of the most common pathogens associated with BRDC is discussed below.

It is well accepted that BRDC has a complex and multifactorial etiology. Disease results from a complex relationship between the pathogen, host, and environment. An interaction of animal susceptibility and response to challenge, various stressors, and environmental pathogen load determine disease severity[7]. Viral pathogens are believed to be the primary invaders that can dampen the host's immune response to subsequent bacterial infection[7].

The major viruses responsible for respiratory disease in feedyard cattle include bovine herpesvirus type 1, bovine respiratory syncytial virus (BRSV), bovine viral diarrahea virus (BVDV), and parainfluenza virus type 3 (PI3)[2]. Bovine herpesvirus type 1 is the causative agent of infectious bovine rhinotracheitis usually causing pyrexia, anorexia, coughing, salivation, nasal discharge, conjunctivitis, inflamed nares, and dyspnea if the larynx becomes occluded with purulent material[23]. Infections from BRSV occur primarily in beef and dairy calves and can result in severe respiratory disease[23]. Pyrexia, anorexia, increased respiratory rate, cough, nasal and lacrimal discharge, and dyspnea (possibly with open-mouthed breathing) are all clinical signs associated with BRSV[23]. On rare occasions PI3 can cause severe respiratory disease, but most infections result in a very mild disease of little concern[12]. Bovine viral diarrhea virus is not generally considered a primary respiratory pathogen but is considered important in the pathogenesis of BRDC due to its documented immunosuppressive effects[17].

The major bacterial species associated with BRDC are *Mannheimia haemolytica*, *Histophilus somni*, *Pasteurella multocida*, and *Mycoplasma bovis*[2]. *Mannheimia haemolytica* is a Gram negative, non-spore forming, facultative anaerobic bacterium, and is the most common pathogen isolated from lungs of cattle with BRDC[23]. Although less frequently cultured, *P. multocida* is a Gram negative bacterium that can also play an important role in BRDC[23]. *Histophilus somni* is a Gram negative, intracellular pathogen rarely associated with classical bronchopneumonia[17]. The role of *M. bovis* as a primary respiratory pathogen is still unknown, but it does play a significant role in chronic respiratory disease and infectious arthritis[2].

Respiratory disease in cattle often yields quite predictive pathology. The cranioventral lung lobes are primarily affected with collapse/consolidation, exudation, fibrin accumulation, pleural adhesions, abscesses, parenchymal fibrosis, and discoloration[3,11,38]. Intuitively, lesions in the cranioventral lung fields are indicative of inhalation of the pathogen as opposed to hematogenous spread[17]. The area affected by lesions spread in a caudodorsal fashion as disease severity progresses[11].

## Anatomical and physiological considerations

There are well documented factors predisposing the bovine to BRDC—transport and time without feed, mixing cattle from different sources, and diet changes among many others[5]. The unique anatomy of the bovine respiratory system both grossly and microscopically offers even more explanation as to why BRDC is the number one disease affecting the feedyard industry.

In all the domestic species the left lung has two lobes, an apical lobe (divided into cranial and caudal segments), and a diaphragmatic (caudal) lobe. In all the domestic species except the horse, the right lung has four lobes, namely, an apical (cranial), a middle (cardiac), an accessory (intermediate), and a diaphragmatic (caudal)[25]. In most domestic species the right cranial lung lobe is ventilated by the cranial bronchus, the exception being pigs and ruminants (artiodactyla, even toed ungulates) where the cranial lung lobe is ventilated by the right cranial bronchus (tracheal bronchus) coming off of the trachea at approximately the third pair of ribs[20,25]. These anatomical differences considered, it is not surprising that BRDC commonly manifests itself with a cranioventral distribution in the lung, namely in the right cranial lung lobe[1].

Selection in beef cattle for genetic lines with greater digestive capacity, muscle mass, milk production or growth rates has collectively increased total body metabolic oxygen requirements relative to the bovine's gaseous exchange capacity[43]. Bovine lungs have about 25% of the lung volume per unit of body weight as compared to the mammalian mean[46].

A physiological comparison of the bovine respiratory system to that of five other mammals (horse, man, goat, dog, and cat) revealed that the bovine respiratory system has a smaller physiological gaseous exchange capacity and a greater basal ventilatory activity (Table 1.5). Cattle at rest use 2.1 times more of their total lung volume and also have three times greater basal airflow rate per unit lung volume than the mean of the other mammals[43] (Table 1.6). Therefore, cattle have smaller gas exchange capacity using more of their total lung volume and using it faster than the five other mammals in that comparative study[43]. Taken together, Veit and Farrell (1978) speculated that this results in a greater exposure rate predisposing cattle to pulmonary accumulation of harmful substances (i.e., pathogens) and therefore to the development of pulmonary lesions[43].

**Table 1.5 Gaseous exchange and basal metabolic oxygen requirements**

| Species | Body Wt. (kg) | Basal Oxygen Consumption (mL/min/kg) | Total Oxygen Consumption (mL/min) | Total Alveolar Surface Area ($m^2$) | Alveolar Surface Area/Total Oxygen Consumption ($m^2$/mL) |
|---|---|---|---|---|---|
| Cat | 2.6 | 510 | 1,326 | 7.3 | 0.0054 |
| Dog | 16.0 | 379 | 6,064 | 46.5 | 0.0078 |
| Goat | 32.0 | 365 | 11,680 | 96.0 | 0.0082 |
| Man | 54.9 | 221 | 12,133 | 63.0 | 0.0051 |
| Horse | 388.8 | 127 | 49,403 | n/a | n/a |
| Cattle | 490.0 | 255 | 124,950 | 316.0 | 0.0025 |
| | | | | | |
| Mean | | | | | 0.0057 |

Table adapted from Veit and Farrell, 1978

**Table 1.6 Basal respiratory parameters**

| Species | Total Lung Vol. (ml) | Tidal Vol. | Percent Basal Use* (%) | Respiration Rate (Resp./min.) | Minute Vol. (ml/min) | Pulmonary Air Flow Rate** |
|---|---|---|---|---|---|---|
| Cat | 340 | 25.5 | 7.5 | 20.5 | 523 | 1.54 |
| Dog | 1,790 | 251 | 14.0 | 20.0 | 5,020 | 2.80 |
| Goat | 4,000 | 310 | 7.8 | 19.0 | 5,890 | 1.47 |
| Man | 4,930 | 544 | 11.0 | 12.0 | 6,528 | 1.32 |
| Horse | 42,000 | 6,000 | 14.3 | 11.0 | 66,000 | 1.57 |
| Cattle | 12,400 | 3,600 | 29.0 | 30.0 | 108,000 | 8.71 |
| | | | | | | |
| Mean | | | | 13.9 | | 2.90 |

* Percent basal use = (Tidal volume (mL) / Total lung volume (mL)) *100

** Pulmonary air flow rate = Percent Basal Use x Respiratory rate = Minute Volume / Total Lung Volume

Table adapted from Veit and Farrell, 1978

## Study objectives

BRDC is the most devastating disease in our feedyards; it inflicts damage both financially and is an animal welfare concern. Disease processes in any animal sector is a complex relationship between the animal (host), the pathogen, and the environment. The respiratory pathogens and subsequent pathology they produce in the cattle feedyard industry have not and will not change. An inability to accurately diagnose disease in the feedyard leads to inaccurate and ineffective treatments. Real time (or chute-side) and cost effective advancements must be made in the way we diagnose respiratory disease.

The stethoscope is one of the most valuable aids to our physical senses for the examination of certain organs[9]. Auscultation is among the most cost-effective diagnostic techniques available in clinical practice[4]. To the author's knowledge there are no studies evaluating the use of the stethoscope for diagnosing BRDC in feedyard cattle. The objectives of these studies are as follows:

1. validate a thoracic auscultation scoring system by correlating ante-mortem lung sounds with post-mortem lung lesions
2. evaluation of thoracic auscultation and rectal temperature as diagnostic tools by way of case outcome (retreatment rates and death loss) in the field.

# CHAPTER 2 - Lung auscultation as a predictor of lung lesions and bovine respiratory disease outcome in feedyard cattle

## Introduction

Bovine respiratory disease complex (BRDC) is the most common, and costly, disease in feedyard cattle. Significant amounts of money are spent on preventing and treating BRDC in the feedyard in just vaccines and antibiotics alone. Loneragan (2001) estimated treatment costs in the calendar year of 1999 to be 45.7 million dollars[17]. This estimation is significantly lower than the $624 million estimated by Smith in 1996[26].

Death loss associated with BRDC in feeder cattle has been well documented. Vogel and Parrott (1994) published a feedyard mortality survey detailing data from 59 feedyards (38,593,575 head of cattle) in seven Midwestern states from January 1990 – May 1993. Deaths due to BRDC were 44.1% of total deaths in these feedyards. Digestive disorders attributed to 25.9%, and "other" causes accounted for 28.6% of all deaths over the three and a half year period[44]. Another estimate is provided by the United States Department of Agriculture (USDA) National Animal Health Monitoring System (NAHMS), established in 1983 to collect, analyze, and disseminate data on animal health, management, and productivity across the United States. Data were collected for 21,753,082 head of cattle from 121 feedyards in 12 states for the period 1994 to 1999 and published in 2000[40]. Loneragan *et al.* (2001) published a paper from these data and found that the mortality ratio tended to increase (P = 0.09) from 10.3 deaths per 1,000 head of cattle in 1994 to 14.2 deaths per 1,000 head of cattle in 1999 for all etiologies. Respiratory mortality ratios increased from 5.4 deaths per 1000 head in 1994 to 8.7 per 1000 head in 1999.

Additionally, they found that cattle entering the feedyard in 1999 had a significant increase in risk (relative risk, 1.46) of dying from respiratory disease as compared to cattle entering the feedyard in 1994[18].

Aside from obvious economic losses from death loss of cattle, there are performance issues attributed to this disease. Gardner *et al.* (1999) found that steers without lesions at slaughter had 11% (1.58 vs. 1.40 kg/d, $P < 0.01$) greater ADG than cattle with lesions[10]. Similarly, Bryant *et al.* (1999) at the Great Plains Veterinary Educational Center showed that lesions present at slaughter had negative effects on ADG of 0.057 lb in single source calves ($P < 0.01$) to as high as 0.65 lb in calves from a commercial feedyard ($P < 0.01$)[3]. More recently researchers in South Africa found that the average negative effect of the presence of lung lesions at slaughter were a 0.023 kg/d reduction ($P = 0.02$) in ADG. Additionally, they also found the presence of lesions at slaughter was associated with a 5.5 day increase in days on feed (DOF)[37].

In the U.S. feedyard system, disease detection starts with the pen riders. Pen riders are in the pens looking at cattle at least once per day for signs of any illnesses. Clinical signs that are used to identify cattle possibly afflicted with BRDC include respiratory rate, respiratory character, rumen fill, observed anorexia, nasal discharge, ocular discharge, and depression[2]. Cattle identified to be exhibiting these signs are then pulled (taken out of the pen for further examination) and taken to the hospital. Once at the hospital, classical feedyard diagnostics consist of examining clinical signs and taking rectal temperatures. Decisions on therapeutic regimens are often outlined in a treatment protocol and are generally based on a rectal temperature greater than an arbitrary number, described as ≥39.7 ºC (103.5 ºF) by Duff and Galyean[7].

Rectal temperatures can vary from the influence of such factors as environmental temperature, relative humidity, exercise, excitement, and anxiety. These changes in rectal temperature are the result of physiologic change rather than a pathologic one[9]. Vogel *et al* (2007) found that for each unit increase in maximum ambient temperature, rectal temperature in all cattle pulled increased 0.07 ºF ($P < 0.01$)[45]. In the same study, they found that the rectal temperatures in cattle pulled and treated for BRDC had no association with the risk of retreatment or mortality[45].

Using elevated rectal temperature as the sole diagnostic tool beyond clinical signs is essentially treating on the basis of depression with undifferentiated fever. Treatments based solely on this may lead to unnecessary (and injudicious) antimicrobial use[2]. The use of a stethoscope to auscultate lungs for clinical diagnosis in humans and animals has been utilized throughout medical history. However, nothing in the literature describes the use of a stethoscope to diagnose BRDC in feeder cattle. Therefore the objectives of this paper are to validate a thoracic auscultation scoring system by correlating ante-mortem lung sounds with post-mortem lung lesions and then evaluate thoracic auscultation and rectal temperature as diagnostic tools to predict case outcome in the feeder cattle treated for BRDC in a commercial setting.

## Materials and Methods

### *Validation Study*

Thirty-six head of cattle were used to validate the use of a lung auscultation scoring system to identify cattle suffering from BRDC. The population of cattle used in the validation study consisted of animals that had been realized from commercial feeding operations. There are several disease processes that can attribute to the realization of cattle from feeding operations.

Cattle can be sent to market early because of severe lameness, chronic digestive diseases, respiratory infections, or many other chronic disease processes.

Twenty-six head were delivered to a small backgrounding feedyard in Booker, Texas and nine head were presented to Kansas State University Veterinary Medical Teaching Hospital (KSU VMTH). Ante-mortem evaluations were performed consisting of general physical examinations including rectal temperature and thoracic auscultation. Lung sounds were scored at the time of examination using a 1 – 10 scoring system (Table 2.1) and lung audiograms were captured with the use of an electronic stethoscope (3M Littman Electronic Stethoscope Model 4100). Lungs were scored systematically with auscultations performed in the area of the cranioventral lung fields and just dorsal to the approximate location of the carina on both the left and right sides of the thorax. Lung sounds were scored independently on the left and right side of each calf.

**Table 2.1 Ante-mortem auscultation scoring system**

| Lung Score | Auscultation Findings |
|---|---|
| 1 – 2 | Normal lung sounds |
| 3 – 4 | Mild lung sounds |
| 5 – 6 | Moderate lung sounds |
| 7 – 9 | Severe lung sounds |
| 10 | Acute interstitial pneumonia |

In addition to general physical examinations, calves in Booker, TX were individually ear tagged with a unique identification system to ensure their proper identification at the packing plant. Several checkpoints were set up within the packing plant in order to ensure the correct lung lesion scores were matched with the correct animal as previously described by Griffin and Perino (1992)[13].

After examination, the cattle in Booker, TX were transported to a nearby abattoir for harvest. At harvest, lungs were evaluated and scored using a scoring system modified from that previously developed by Bryant *et al.* (1999)[3] (Table 2.2). Lung lesion scores were determined for both left and right lung lobes. Digital pictures were taken of all lungs post-mortem.

**Table 2.2 Post-mortem lung lesion scoring system**

| Lesion score | Post-mortem Findings |
|---|---|
| 0 | Normal lung / No lesions |
| 1 | Total affected area or volume involving less than one cranioventral lobe (<5% lung volume) and/or adhesions (fibrin tags) |
| 2 | Adhesions affecting more than one cranioventral lobe (>5% lung volume) and/or missing piece of lung |
| 3 | Missing lung >15% of total lung area (>three cranioventral lobes) and/or active tracheal-bronchial lymph nodes |

Cattle deemed chronically ill from a grow yard in Centralia, KS were presented to KSU VMTH for diagnostic evaluation. All cattle were given similar ante-mortem examinations as the cattle in Booker, TX. Lung auscultation scores were assigned similarly. All calves were humanely euthanized and a complete necropsy was performed. Lung lesion scoring was performed as described in the previous paragraph. Digital pictures were taken of all lungs post-mortem.

## *Field Study*

A retrospective cohort study was conducted using data obtained from three commercial feedyards. One feedyard is located in Western Kansas (KS) one in Western Nebraska (NE), and the third feedyard is located in Washington State (WA). Cattle enrolled in the study (n = 4,341 head) were treated for BRDC between January and October 2007 by trained feedyard personnel.

Individual animal data were obtained from all cattle diagnosed and treated by trained feedyard personnel regardless of etiology. Data recorded included animal identification, rectal temperature, lung score, and antibiotic therapy at first treatment. Cases included in the study had to meet the following enrollment criteria: the animal was pulled for clinical signs associated with respiratory disease, and the treatment records included a lung score, rectal temperature, and treatment regimen was recorded. Additionally if the animal died its death had to be attributed to BRDC, as deemed by trained feedyard personnel. Pen riders at each feedyard removed calves from the home pen for BRDC treatment based on clinical signs that included increased respiratory rate and/or effort, decreased rumen fill, observed anorexia, nasal/ocular discharge, and depression.

Cases meeting the requirements for inclusion in the study totaled 4,341 head of cattle (KS, n = 287; NE, n = 404; WA, n = 3,650). After the animal had been enrolled in the study the animal treatment outcomes were observed. Treatment outcome data were recorded by feedyard personnel utilizing the animal health computer. The outcome data tracked for this study included subsequent BRDC treatment or death of the animal.

## Statistical Analysis

In the validation study, lung auscultation scores (LAS) were recorded on the left and right side of each animal and lung lesion scores (LLS) were recorded for both the left and right lung lobes. Data from both the left and right LAS and LLS were analyzed separately to look for an effect of side of animal that the observations were taken. There were no outcome differences for data recorded on the left or right side of the animal. Therefore, LAS and LLS obtained from the left and right side of the animal were averaged for each animal. Statistical analysis was performed with average LAS as the dependent variable to determine the extent of correlation with LLS utilizing the linear regression procedures of SAS (Statistical Analysis Software, Version 9.1.3, Copyright (c) 2002-2003 by SAS Institute Inc., Cary, NC, USA).

In the field study, three feedyards were used but the number of calves (or experimental units) from each feedyard were not equally represented and although the observers (the persons assigning LAS), were trained by the same veterinarian, they were different at each feedyard. Mixed model logistic regression was used and a random statement was included to account for feedyard as a random variable. The model also accounted for clustering of lung scores within a feedyard so that all observations within a feedyard were correlated with each other more highly than those between feedyards.

Eight different treatment regimens were utilized by the three feedyards and therapeutic decisions were made depending on clinical findings, rectal temperature and LAS. Therefore, it was assumed that there could be a treatment effect on case outcome (retreatment rate). The antibiotic regimen selected was highly dependent on feedyard and was therefore assumed to be controlled by including feedyard as a random variable in the statistical model.

Risk of retreatment and death by LAS and rectal temperature were modeled using logistical regression. Predicted values were obtained with 95% confidence levels using a model based on either LAS or rectal temperature. Only animals receiving LAS of 2 – 9 were included in the risk analysis. Calves that were scored 1 received no treatment (or were observed for further signs of BRDC) nearly 94% of the time (105/112) and therefore coming back to the hospital for treatment would not constitute a retreatment. Calves with LAS of 10 were diagnosed as cattle suffering from acute interstitial pneumonia (AIP) which is not believed to be of infectious origin so treatment with antibiotics are unwarranted; additionally AIP is not usually included in the classical definition of BRDC.

# Results

## *Validation Study*

Two calves were removed before data analysis; one escaped the chute before lung sounds could be captured and the other calf was removed from the study because the audiogram had too much background noise to adequately score lung sounds.

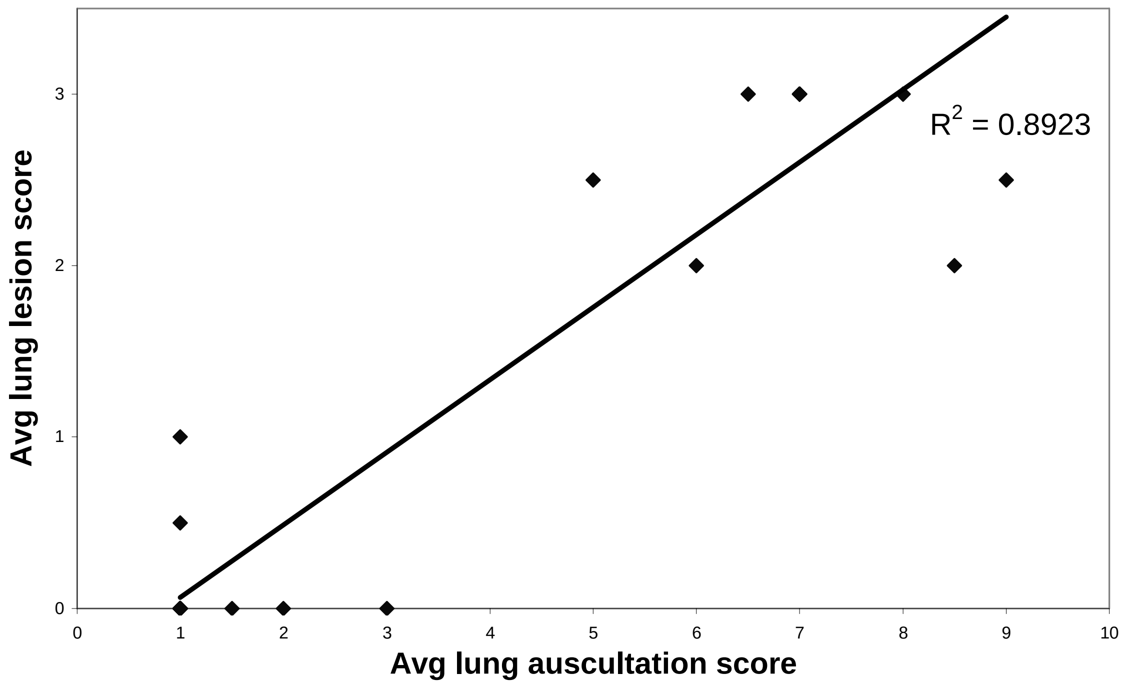
Twenty cattle had LAS of 1 and LLS of 0 and were therefore likely sent to market early for reasons other than chronic respiratory disease due to there being no pulmonary pathology. Eleven head of cattle received LLS of 3, or had severe lung pathology, and were likely realized due to chronic respiratory disease. The number of calves that were scored in each LAS and LLS are given in Table 2.3. A majority of the observations received LAS of 1, 7, 8, or 9 and subsequently received LLS of 0 or 3.

The results of the linear regression (Figure 2.1) revealed a strong positive correlation ($P < .0001$) between ante-mortem LAS and post-mortem LLS. Forty-four percent of all cattle had lung lesions at post-mortem examination. These data indicate that lung auscultation is predictive of lung lesions associated with BRDC. A field study to evaluate the ability to predict case outcome or treatment therapies due to lung auscultation score was a logical next step.

**Table 2.3 Ante-mortem lung auscultation and post-mortem lung lesion scores for thirty-four head of cattle realized from commercial feeding operations. On the left is the number of calves that received each lung auscultation score by the side of the body on which the observation was taken. On the right is the number of calves that received each lung lesion score for the left and right lung lobes.**

| Lung auscultation score | | | | Lung lesion score | | |
|---|---|---|---|---|---|---|
| | Left | Right | | | Left | Right |
| 1 | 20 | 18 | | 0 | 19 | 20 |
| 2 | 0 | 1 | | 1 | 3 | 1 |
| 3 | 1 | 3 | | 2 | 2 | 2 |
| 4 | 0 | 1 | | 3 | 10 | 11 |
| 5 | 0 | 0 | | | | |
| 6 | 0 | 1 | | | | |
| 7 | 8 | 4 | | | | |
| 8 | 3 | 4 | | | | |
| 9 | 2 | 2 | | | | |
| 10 | 0 | 0 | | | | |

**Figure 2.1 Scatter plot of average ante-mortem lung auscultation score and post-mortem lung lesion score from thirty-four head of cattle realized from commercial feeding operations. (n = 34) P < .0001**



### *Field Study*

Cattle treated for BRDC which met the inclusion criteria described in the materials and methods for the field trial totaled 4,341 head. The distributions of calves within each LAS are illustrated in Figure 2.2. Ninety-six percent of cattle were observed to have a LAS range from 2 to 6 at the time of first BRDC treatment (Figure 2.2).

Retreatment rate was defined as the percentage of cattle that did not respond to the first BRDC treatment and were subsequently treated a second time. Case fatality rates were the percentage of cattle that were treated for BRDC and died divided by the total number of cattle treated for BRDC. Retreatment and case fatality rates for assigned LAS for cattle treated for BRDC in all three feedyards are shown in Table 2.4. Forty one percent of calves assigned a LAS of 1 at first BRDC treatment were diagnosed and treated for BRDC. The case fatality rate for cattle exhibiting a LAS of 1 was, 1.8%. The retreatment rates and case fatality rates for cattle treated for BRDC increased as LAS increased.

Rectal temperatures ranged from 100.1 to 108.0 ºF (37.8 – 42.2 ºC) in all claves diagnosed and treated for clinical signs associated with BRDC. Summary statistics of the number of calves, retreatment, and case fatality rates within each rectal temperature range from all three feedyards can be found in Table 2.5. Twenty-six percent (1135/4341) of the cattle had rectal temperatures less than or equal to 104.0 ºF with a retreatment rate of 28.2% and a case fatality rate of 2.5%. Seventy-four percent had rectal temperatures greater than 104.0 ºF with a retreatment rate of 40.6% and a case fatality rate of 5.1%.

Number of cattle treated, retreatment rates and case fatality rates for each feedyard and all feedyards combined are listed in Table 2.6. Retreatment rates were 37.3% indicating a first treatment success of 63.7% in all feedyards combined, retreatment rates were highest in the WA feedyard and lowest in the NE feedyard. The combined case fatality rate for the three feedyards was 4.4%, with case fatality rate being the highest in the KS feedyard and lowest in the WA feedyard.

Lung auscultation score was predictive for retreatment (Figure 2.3, $P < .0001$) and death loss (Figure 2.4, $P < 0.0001$) in calves diagnosed and treated for BRDC. Rectal temperature was also predictive of retreatment (Figure 2.5, $P < .0001$) and death loss (Figure 2.6, $P < .0001$) in calves treated for BRDC. The models have predicted risk (i.e., odds) with upper and lower 95% confidence intervals. The confidence levels are symmetrical around the log of the risk therefore there is a greater difference from the upper confidence level than the lower confidence level. This is a reflection of the fact that it is a logistical model rather than a normal model.

The likelihood of a calf being retreated which was assigned a LAS of 2 at first treatment for BRDC was 13% while the retreatment rate for cattle assigned a LAS of 9 was 63%. That is an increase in the risk of retreatment of 388% as LAS moves from 2 to a 9 (Figure 2.3). The risk of death from BRDC increases 223%, from 1.7% to 39% as LAS severity proceeds from a score of 2 to 9 (Figure 2.4). A rise in rectal temperature from 100 to 108 ºF correlated with a 266% increase in likelihood to be retreated for BRDC (Figure 5). The risk of death from BRDC increased 196% as rectal temperature proceeded from 100 to 108 ºF (Figure 2.6).

**Figure 2.2 Distribution of calves by lung auscultation score received at the time of first treatment for bovine respiratory disease complex in three feedyards from three different states.**

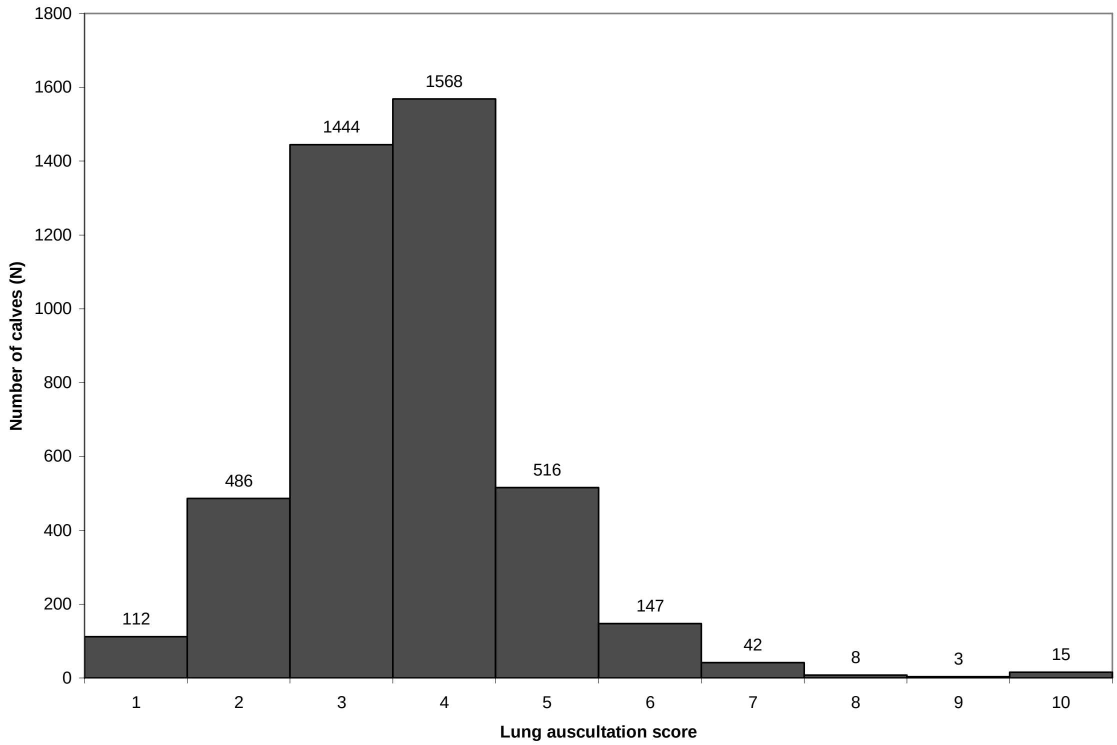


**Table 2.4 Number of calves, retreatment rates, and case fatality rates for each lung auscultation score reported from three feedyards from three different states.**

| Lung auscultation score | Number of calves (n) | Retreatment rate, %* | Case fatality rate, %** |
|---|---|---|---|
| 1 | 112 | 41.1 | 1.8 |
| 2 | 486 | 25.3 | 1.0 |
| 3 | 1444 | 35.0 | 2.8 |
| 4 | 1568 | 39.9 | 4.2 |
| 5 | 516 | 45.3 | 8.1 |
| 6 | 147 | 40.1 | 14.3 |
| 7 | 42 | 35.7 | 26.2 |
| 8 | 8 | 37.5 | 25.0 |
| 9 | 3 | 66.7 | 33.3 |
| 10 | 15 | 46.7 | 6.7 |

* Retreatment rate = (calves pulled for second treatment/calves pulled for first treatment)*100

** Case fatality rate = (calves that died/calves pulled for first treatment)*100

**Table 2.5  Number of calves, retreatment rates, and case fatality rates for each gradation in rectal temperature reported from three feedyards from three different states.**

| Rectal temperature, ºF | Number of calves, (n) | Retreatment, %* | Case fatality rate, %** |
|---|---|---|---|
| 100-101.0 | 40 | 47.5 | 5.0 |
| 101.1-102.0 | 133 | 24.8 | 0.0 |
| 102.1-103.0 | 319 | 27.3 | 2.8 |
| 103.1-104.0 | 643 | 28.1 | 2.6 |
| 104.1-105.0 | 1120 | 33.3 | 3.1 |
| 105.1-106.0 | 1105 | 41.1 | 4.8 |
| 106.1-107.0 | 733 | 45.7 | 6.0 |
| 107.1-108.0 | 248 | 56.0 | 12.9 |

* Retreatment rate = (calves pulled for second treatment/calves pulled for first treatment)*100

** Case fatality rate = (calves that died/calves pulled for first treatment)*100

**Table 2.6 Statistical summary of number of calves, retreatment, and case fatality rates by each individual feedyard and for all feedyards in the field study.**

| | Number of calves (n) | Retreatment rate, (%)* | Case fatality rate, (%)** |
|---|---|---|---|
| All feedyards | 4341 | 37.3 | 4.4 |
| KS feedyard | 287 | 28.6 | 8.0 |
| NE feedyard | 404 | 12.1 | 6.7 |
| WA feedyard | 3650 | 40.8 | 3.9 |

* Retreatment rate = (calves pulled for second treatment/calves pulled for first treatment)*100

** Case fatality rate = (calves that died/calves pulled for first treatment)*100

**Figure 2.3 Predicted risk of a calf being pulled a second time for treatment of BRDC by lung auscultation score modeled using logistical regression. The solid line is the risk of retreatment. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P < .0001)**

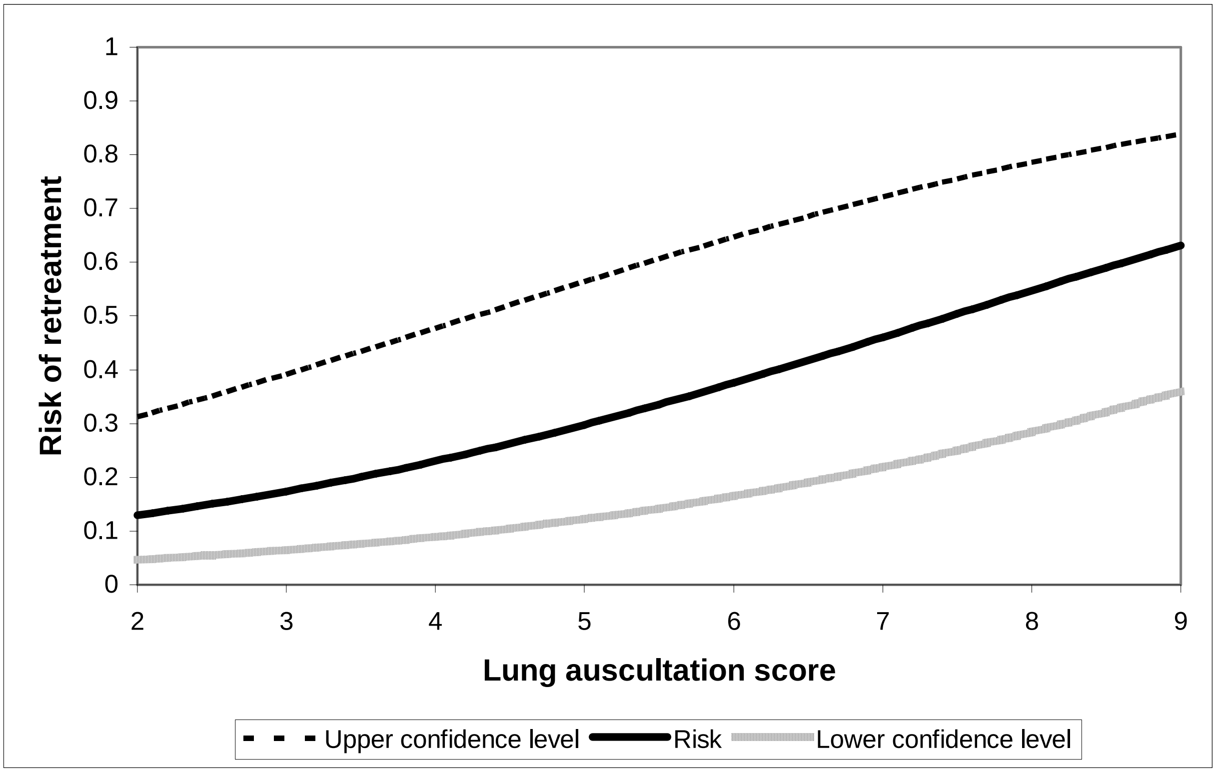


**Figure 2.4 Predicted risk of a calf dying from BRDC by lung auscultation score modeled using logistical regression. The solid line is the risk of death. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P < .0001)**

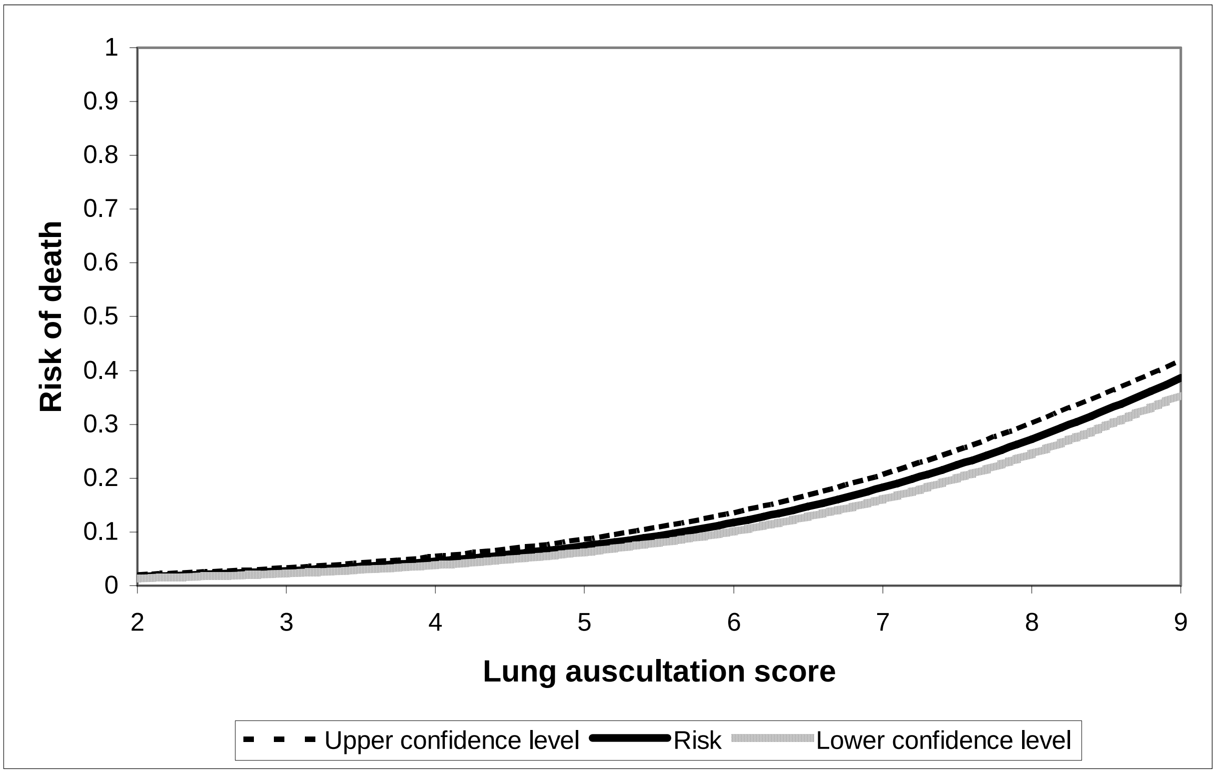


**Figure 2.5 Predicted risk of a calf being pulled a second time for treatment of BRDC by rectal temperature modeled using logistical regression. The solid line is the risk of retreatment. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P < .0001)**

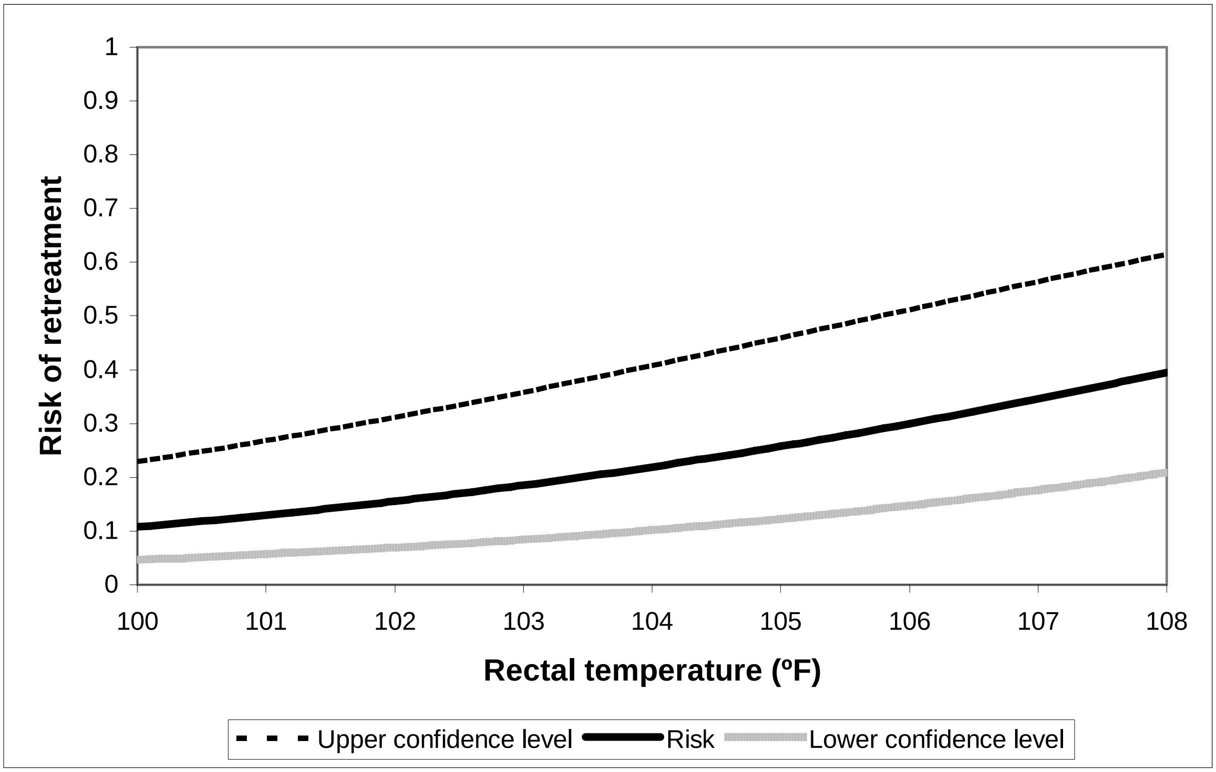
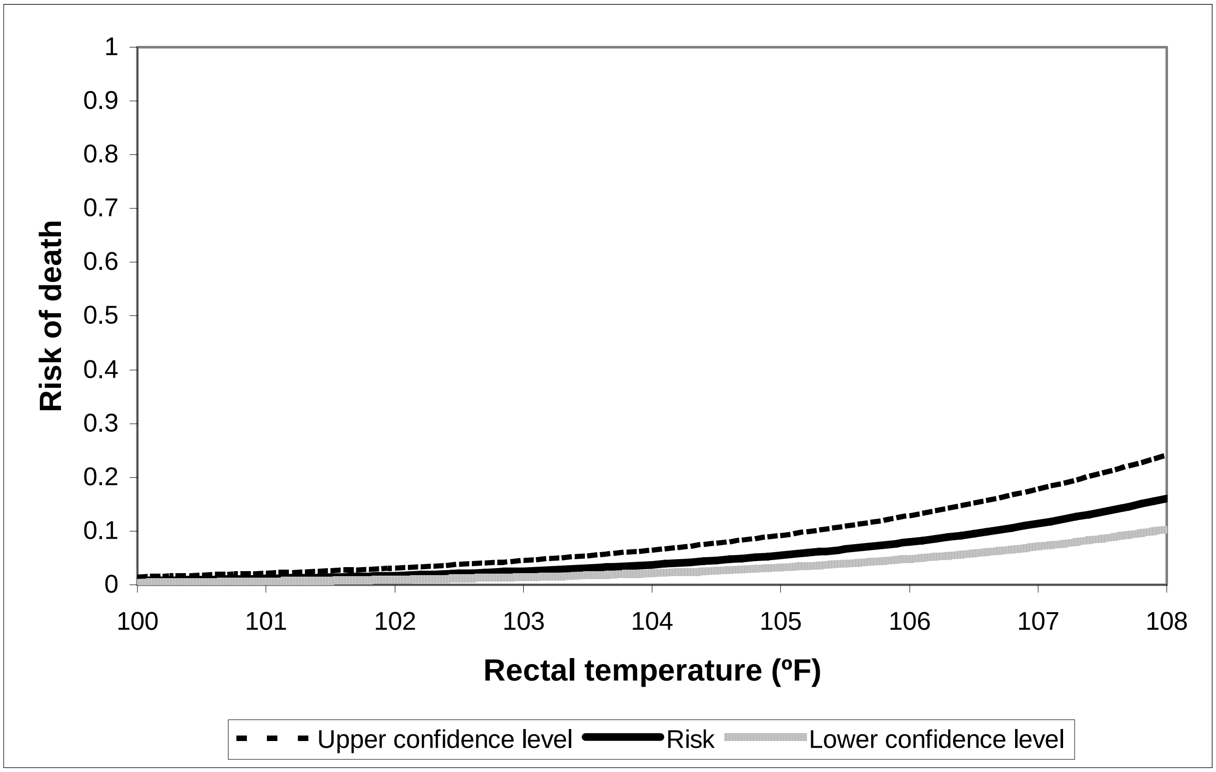


**Figure 2.6 Predicted risk of a calf dying from BRDC by rectal temperature modeled using logistical regression. The solid line is the risk of death. The dashed line (upper conf. level) and gray line (lower conf. level) represent the 95% confidence intervals of the risk. (P < .0001)**



## Discussion

The studies described here are the first to show the validation of ante-mortem LAS to predict LLS in feedyard cattle. These studies are also the first to report that LAS are predictive of retreatment rates and case fatality rates in feeder cattle diagnosed and treated for BRDC. As LAS in cattle increase in severity the likelihood of finding severe post-mortem lung lesions increase. In the field as LAS increased the risk of a calf being retreated or dying from BRDC increased.

The findings of the validation study are consistent with other published reports of post-mortem lung lesion examination in feedyard cattle. These similarities in post-mortem lung lesions were interesting due to the fact that cattle involved in the study reported here were being realized due to poor performance or being diagnosed as chronically ill while previous reports involved cattle shipped as fat cattle to a harvest facility. Forty-two percent of all the cattle in this validation study had lung lesions at post-mortem examination. Bryant *et al.* (1999) found that 54% of all cattle from a commercial feedyard in Nebraska had lung lesions present at slaughter[3]. Gardner *et al.* (1999) and Thompson *et al.* (2006) report similar results of 37% and 43%, respectively[10,37]. Wittum *et al.* (1996) report slighter higher lesion incidence rates at 72%[48].

Very little literature exists on relationships between diagnostic techniques and case outcomes. Vogel *et al.* (2007) evaluated case outcomes subsequent to BRDC treatment for relationships to the following clinical parameters: packed cell volume, plasma total protein, rectal temperature, maximum ambient temperature, body weight, and changes in body weight. They found only one variable was associated with treatment outcome. A lower body weight relative to the estimated average pen weight (or changes in body weight) was associated with an increased risk of cattle not surviving to slaughter[45].

The field study reported here showed that rectal temperature was predictive of retreatment and case fatality rates in cattle treated for BRDC which is in disagreement with Vogel *et al.* (2007). In their study, rectal temperature in cattle treated for BRDC was correlated with ambient temperature when treatments occurred[45]. We did not track the ambient temperatures in the field study. However, the study conducted by Vogel *et al.* (2007) was conducted in a feedyard in Central KS during the months of June through August. Their study recorded record high temperatures (some over 100 ºF) during their study. It is likely that ambient temperature was much more variable during our field study based on time of year in which it was conducted (October to June) or based on a geographical location (WA, NE and KS).

Retreatment rates and case fatality rates differed between the feedyards included in this study. The three feedyards in this field study had retreatment rates that ranged from 12.8 – 40.1% and case fatality rates from 3.9 – 8%. The range of these data is somewhat surprising. Although there was no feedyard by LAS interaction, the feedyard in WA had significantly higher retreatment rates than the two feedyards in KS and NE. The opposite was true for case fatality rates, with the KS and NE yards having higher values than the WA feedyard. The feedyard in WA also had the most observations (3,650 head) compared to the other two feedyards. Similar biases could be applied to the treatment regimen outcome data reported in the field study.

Evaluator bias at the time of lung auscultation scoring could affect the results of the field study. The clinical appearance of a calf (clinical signs of BRDC; i.e., depression, nasal discharge, etc) as it is evaluated in the hospital chute could clearly bias the evaluator's interpretation and scoring upon thoracic auscultation. Treatment regimen selected after evaluation could be a confounding variable. Lastly, as mentioned before, 84 percent of the data came from one feedyard and may introduce a feedyard effect. Feedyard was therefore modeled as a random variable.

Further research utilizing the stethoscope to evaluate the effectiveness of BRDC treatment and cattle performance is needed. Today, newer antimicrobial products used for BRDC treatment are costly compared to earlier adopted therapy options. A controlled study evaluating case outcomes in cattle treated with different antimicrobial therapies within different LAS could improve case outcomes or decrease treatment costs in cattle suffering from BRDC. Future studies should measure performance and subsequent carcass characteristics in cattle within different LAS classes. These data could be used by producers to change marketing strategies of cattle to maximize profitability.

In conclusion, lung auscultation scoring requires minimal capital input and can be performed chute side. These data indicate that lung auscultation can be used to predict case outcomes for BRDC. The results of this study may serve veterinarians and managers as they design treatment protocols better aimed at those animals associated with a higher risk of treatment failure or death from BRDC.

## References


1. Allen JW, Viel L, Bateman KG, *et al.*: Cytological findings in bronchoalveolar lavage fluid from feedyard calves: associations with pulmonary microbial flora. *Can J Vet Res* 56:122-126, 1992.

2. Apley MD: Bovine respiratory disease: pathogenesis, clinical signs, and treatment in light weight calves. *Vet Clin Food Anim* 22:399-411, 2006.

3. Bryant LK, Perino LJ, Griffin DD, *et al.*: A method for recording pulmonary lesion of beef calves at slaughter, and the association of lesions with average daily gain. *Bov Pract* 33(2):163-173, 1999.

4. Curtis RA, Viel L, McGuirk SM, *et al.*: Lung sounds in cattle, horses, sheep and goats. *Can Vet J* 27:170-172, 1986.

5. Cusack PMV, McMeniman N, Lean IJ: The medicine and epidemiology of bovine respiratory disease in feedyards. *Aus Vet J* 81(8):480-487, 2003.

6. DeRosa DC, Mechor GD, Staats JJ, *et al.*: Comparison of *Pasturella* spp. Simultaneously isolated from nasal and transtracheal swabs from cattle with clinical signs of bovine respiratory disease. *J Clin Microbio* 38(1):327-332, 2000.

7. Duff GC, Galyean ML: Board-invited review: recent advances in management of highly stressed, newly received feedyard cattle. *J Anim Sci* 85:823-840, 2007.

8. Edwards A: Respiratory disease of feedyard cattle in central USA. *Bov Pract* 30:5-7, 1996.

9. Fox FH: Diagnostic techniques for diseases of cattle. *J Am Vet Med Assoc* 161(11):1251-1255, 1972.

10. Gardner BA, Dolezal HG, Bryant LK, *et al.*: Health of finishing steers: effects on performance, carcass traits, and meat tenderness. *J Anim Sci* 77:3168-3175, 1999.

11. Glock RD: Diagnostic and feedyard pathology. *Vet Clin Food Anim* 14(2):315-324, 1998.

12. Griffin DD: Etiology, pathogenesis and clinical signs of bovine respiratory disease. *Bovine respiratory disease: sourcebook for the veterinary professional* Trenton, NJ: Veterinary Learning Systems, 1996;6-11.

13. Griffin DD, Perino, LJ: Disease monitoring in packing houses. *Amer Assoc of Bov Pract: Conf Proc.* XXV 2:343-350, 1992

14. Irsik M, Langemeier M, Schroeder T, *et al.*: Estimating the effects of animal health on the performance of feedyard cattle. *Bov Pract* 40(2):65-74, 2006.

15. Jubb KVF, Kennedy PC, Palmer N: *Pathology of domestic animals*. 3rd ed. Orlando, FL: Academic Press, Inc., 1985.

16. Larson RL: Effect of cattle disease on carcass traits. *J Anim Sci* 83(E. Suppl):E37-E43, 2005.

17. Loneragan GH: Acute interstitial pneumonia, bovine respiratory disease complex and potential pneumotoxicity in feedyard cattle. *Department of Clinical Sciences*. Fort Collins, Colorado: Colorado State University, 2001.

18. Loneragan GH, Dargatz DA, Morley PS, *et al.*: Trends in mortality ratios among cattle in US feedyards. *J Am Vet Med Assoc* 219(8):1122-1127, 2001.

19. Mariassy AT, Plopper CG, Dungworth DL: Characteristics of bovine lung as observed by scanning electron microscopy. *Anat Rec* 183:13-26, 1975.

20. Nickel R, Schummer A, Seiferle E, *et al.*: Respiratory System. *The viscera of the domestic animals.* New York, NY: Springer-Verlag, 1973;245.

21. Perino LJ, Apley MD: Clinical trial design in feedyards. *Vet Clinic Food Anim* 14(2):343-365, 1998.

22. Reece WO: Respiration in mammals In: Reece WO, ed. *Dukes' Physiology of Domestic Animals*. 12 ed. Ithaca, New York: Cornell University Press, 2004;143.

23. Respiratory system In: Kahn CM, ed: *The Merck Veterinary Manual*. 9 ed. Whitehouse Station, NJ: Merck & Co., Inc., 1192-1197, 2005.

24. Rybicka K, Daly BDT, Migliore JJ, *et al.*: Ultrastructure of pulmonary alveoli of the calf. *Am J Vet Res* 35(2):213-222, 1974.

25. Sisson S, Grossman JD. *The anatomy of the domestic animals*. 5th ed. Philadelphia, PA: W.B. Saunders Company, 1975.

26. Smith RA: Introduction. *Bovine Respiratory Disease*. United States of America,: Veterinary Learning Systems Co, Inc., 1996;5.

27. Snowder GD, Van Vleck LD, Cundiff LV, *et al.*: Bovine respiratory disease in feedyard cattle: environmental, genetic, and economic factors. *J Anim Sci* 84:1999-2008, 2006.

28. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1992-93.

29. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1993-94.

30. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1994-95.

31. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1995-96.

32. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1996-97.

33. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1997-98.

34. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1998-99.

35. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 1999-2000.

36. Texas A&M Ranch to Rail Summary Report. Texas Ag Ext Svc. Texas A&M University, College Station, TX, 2000-2001.

37. Thompson PN, Stone A, Schultheiss WA: Use of treatment records and lung lesion scoring to estimate the effect of respiratory disease on growth during early and late finishing periods in South African feedyard cattle. *J Anim Sci* 84:488-498, 2006.

38. Thomson RG: The pathogenesis and lesions of pneumonia in cattle. *Compend Contin Educ* 11(3):S403-S411, 1981.

39. USDA. 2001. Info sheet: Treatment of respiratory disease in U.S. feedyards, 2001. USDA:APHIS:VS, CEAH, National Animal Health Monitoring System. Fort Collins, CO. #N347.1001.

40. USDA. 2000. Changes in the U.S. feedyard industry, 1994-1999. USDA:APHIS:VS, CEAH, National Animal Health Monitoring System. Fort Collins, CO. #N327.0800.

41. USDA. 2000. Part III: Health management and biosecurity in U.S. feedyards, 1999. USDA:APHIS:VS, CEAH, National Animal Health Monitoring System. Fort Collins, CO. #N336.1200.

42. Van Donkersgoed J, Schumann FJ, Harlan RJ, *et al.*: The effect of route and dosage of immunization on the serological response to a *Pasteurella haemolytica* and *Haemophilus somnus* vaccine in feedyard calves. *Can Vet J* 34:731-735, 1993.

43. Veit HP, Farrell RL, *et al.*: The anatomy and physiology of the bovine respiratory system relation to pulmonary disease. *Cornell Vet* 68:555-581, 1978.

44. Vogel GV, Parrott C: Mortality survey in feedyards: the incidence of death from digestive, respiratory, and other causes in feedyards on the Great Plains. *Food Anim Compend* 16:227-234, 1994.

45. Vogel LC, Thomson DU, Loneragan GH, *et al.*: Clinical assessment and adverse health outcomes in feeder cattle treated for bovine respiratory disease complex. *Bovine Conference on Health and Production* Kansas State University College of Veterinary Medicine, Manhattan, KS. April 27, 2007, p 85 [abstract].

46. Weekely LB, Veit HP: Potential morphologic and physiologic factors that may predispose the bovine lung to respiratory diseases. *Food Anim Compend* 17(7):974-982, 1995.

47. Wittum TE, Perino LJ: Passive immune status at postpartum hour 24 and long-term health and performance of calves. *Am J Vet Res* 56(9):1149-1154, 1995.

48. Wittum TE, Woollen NE, Perino LJ, *et al.*: Relationships among treatment for respiratory tract disease, pulmonary lesions evident at slaughter, and rate of weight gain in feedyard cattle. *J Am Vet Med Assoc* 209(4):814-818, 1996.

49. Woolums AR, Loneragan GH, Hawkins LL, *et al.*: Baseline management practices and animal health data reported by US feedyards responding to a survey regarding acute interstitial pneumonia. *Bov Practi* 39(2):116-124, 2005.